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Plant Breeding: the Art of Bringing Science to Life

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Paving the way towards the development of biomass sorghum: a transdisciplinary approach for the development of new sorghum varieties

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Plant biomass is expected to become an essential source to substitute fossil Carbon used currently for energy and biomaterials. As a C4 grass, Sorghum has an efficient photosynthesis which results in a high biomass production and is a promising candidate species for the development of biomass value chain. To reach this objective a transdisciplinary approach merging material sciences, histology, biochemistry, physiology, modeling, genetics and breeding is being developed.

Firstly, biomass traits affecting the properties of different end-products were identified through the combined efforts of materials scientists, process developers and geneticists. We showed that high cellulose content combined with low biomass digestibility is required for polymer biocomposites in order to ensure their thermal and mechanical resistances. At the opposite, this combination of traits is negatively linked to the methane production potential.

Secondly, on some contrasted genotypes, the traits of interest where characterized all along the sorghum development in different water regimes in order to identify their patterns of accumulation / degradation and their response to abiotic constraints. Transcriptome analysis was also performed to clarify the gene regulatory network underlying these traits. Relationships between the biomass production and biomass quality related traits were explored through a modeling approach. It allowed studying the relevance of different ideotypes according to the crop management and environmental constraints.

Thirdly, the genetic determinism of the traits of interest was explored in order to optimize the breeding efficiency for the development of new ideotypes. Allele discovery in broad based panels aiming to build a general library of genomic regions of interest was performed simultaneously with the development of more specific breeding schemes dedicated to the analysis of particular traits and breeding optimization for specific ideotypes. Three connected broad-based association panels were phenotyped for biomass traits highlighted in previous steps. Various trials encompassing different years and locations (tropical or temperate) were analyzed through GWAS analysis using a large SNP dataset. Some promising candidate genes were identified taking advantage of a comparative genomic approach with other species. As a complementary approach, dedicated breeding designs for bioethanol, methane or biocomposites production were used to optimize the identification of the genomic regions of interest and develop new elite parental lines.

We expect that the use of this transdisciplinary approach will provide the sorghum community with relevant generic molecular tools and elite parental lines to monitor sorghum ideotype development adapted to the different uses.